Development and Testing an Energetic Charged Particle Prototype Instrument with a Novel Synthetic Diamond Cherenkov Radiator

Completed Technology Project (2018 - 2021)

Project Introduction

Solar Energetic Particle (SEP) events accelerate ions and electrons over a wide range of energies in processes that are still not fully understood. The energy spectra of SEP events is one key aspect in studying particle acceleration and propagation. Over limited energy ranges, SEP spectra are often approximated by a power law; over the full energy range, SEP events exhibit changing spectral shapes (e.g. "knees", "roll-overs" and "cut-offs"). Measurements of such features is often compromised by the need to combine measurements from more than one instrument, each with its own limited energy range. Even if there are no gaps between the energy intervals of the instruments, differing systematics can severely impact the data. A single instrument capable of measurements over a continuous and extended energy range would offer vastly more reliable measurement of the energy spectra of SEP events. For energies from ~1 MeV upward, solid-state detectors (SSDs) are the primary tool for measuring particle energies and composition for space-based instruments. Particles that stop in instruments are measured using the dE/dx versus residual energy technique, while penetrating particles are measured using the multiple (at least two) dE/dx technique. As the energy increases, the resolution of the later technique rapidly declines. For typical instruments, ~100 MeV for protons is the upper limit of the multiple dE/dx technique. Additional SSDs can extend the range, though the resulting increased instrument length decreases geometrical factors and statistics for higher energies, and mass increases as well. Because the SEP spectra often exceed ~100 MeV, other techniques are employed to extend the instrument energy range upward. Cherenkov detectors are a common technique for extending energy measurements for energetic particle telescopes. Examples of space-based instruments that have used Cherenkov detectors include the CRNC on IMP-8 and the KET on Ulysses. The biggest limitation to the use of Cherenkov radiators in past designs has been the gap between the energy where the SSD measurements lose resolution and the minimum energy threshold of suitable Cherenkov radiators. In conjunction with Applied Diamond, Inc., we propose to develop and test a Cherenkov detector based on large area (presently up to 5 cm diameter) layers of synthetic diamond. Such a radiator would take advantage of diamond's high index of refraction (n = 2.42) to attain an energy threshold (~95 MeV for protons), nearly ideal for use with Si detector stacks. A diamond Cherenkov detector would extend the energy reach of an instrument to >200 MeV. This would not only double the energy reach, but also attain the energy threshold of sapphire Cherenkov detectors (n = 1.76, proton threshold of ~200 MeV) which could be added to achieve still higher energy measurements if required. Similarly, a plastic Cherenkov detector (n = 1.5, threshold ~300 MeV) could further extend the energy measurements to ~450 MeV. Thus a single instrument could provide measurements over a continuous energy interval from ~1-450 MeV for protons with no breaks in the measured energy spectra.

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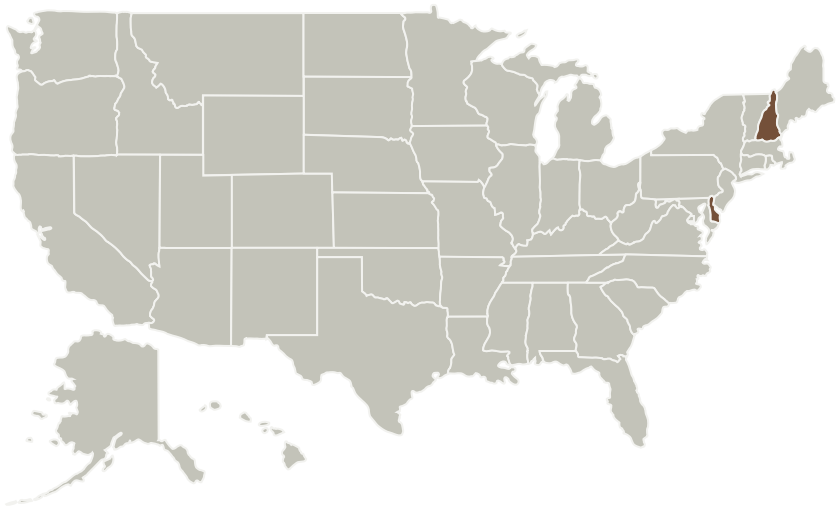
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of New Hampshire-Main Campus	Lead Organization	Academia	Durham, New Hampshire
Applied Diamond, Inc.	Supporting Organization	Industry	

Primary U.S. Work Locations	
Delaware	New Hampshire

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

University of New Hampshire-Main Campus

Responsible Program:

Heliophysics Technology and Instrument Development for Science

Project Management

Program Director:

Roshanak Hakimzadeh

Program Manager:

Roshanak Hakimzadeh

Principal Investigator:

James J Connell

Co-Investigators:

Lisa Scigliano
Clifford Lopate
Joseph Tabeling

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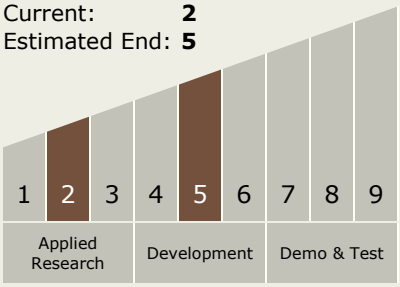
Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **5**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.3 In-Situ Instruments and Sensors
    - TX08.3.1 Field and Particle Detectors

Target Destination

The Sun